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THE IMPORTANCE OF HYDRAULICS OF SURFACE IRRIGATION[a]

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SUMMARY

Surface irrigation is a complex hydraulic phenomenon. The hydraulic elements involved in surface irrigation are listed and discussed. Relating these hydraulic elements is the key to efficient irrigation, good design, and a permanent agriculture.

INTRODUCTION

A general perspective of irrigation and its inherent problems are essential to seeing clearly need, scope, function, and importance of hydraulics in attacking our irrigation problems. The purpose of this paper will be to first outline the objective of irrigation and to point out some of the problems which automatically arise as soon as we attempt to irrigate. How these problems are related to hydraulics will be shown in general terms. The hydraulic variables involved in surface irrigation are not generally understood and the importance of these variables in surface irrigation are often overlooked. A technical discussion of these hydraulic relationships is beyond the scope of this paper. The purpose herein is to show that it is important to understand the hydraulics of surface irrigation if we are to develop a permanent irrigated agriculture.

Consideration will be given to the general problem of surface irrigation, sprinkler irrigation being a special case of the more complex surface irrigation analysis.

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conditions even on the same field. Extrapolation to other fields is very difficult and hazardous. The Soil Conservation Service technicians fully realize this limitation and are making commendable advancements in defining principals which can be used to predict future conditions.

A sound but practical mathematical expression is needed to describe the hydraulic features of the flow. After such a relation has been developed, the results of field trials will be more meaningful and can be used more satisfactorily to predict future conditions or conditions existing on adjacent lands.

Fundamental Hydraulic Characteristics of the Flow

Before the component aspects of the flow can be related, a clear physical picture of the phenomena is needed. To begin the analysis, refer to Fig. 1 showing a schematic view of border irrigation. The basic variables involved in the hydraulics of surface irrigation are as follows:

(1) Rate of application of the water.
(2) Intake rate, rate of movement of the water into the soil.
(3) Rate of advance of water over the land surface.
(4) Roughness of the surface.
(5) Shape of the flow channel; whether it is a border, a corrugation, or a given shaped furrow.
(6) Slope of the land.
(7) Erosion hazard.
(8) Fluid characteristics of the water, affected primarily by temperature.

Some of these quantities can be expressed in terms of other variables. For example, the intake rate can be replaced by the rate of advance of the wetting front down through the soil and the degree of saturation of the soil. Likewise, the location on the soil surface of the advancing water front and the shape of the moisture penetration curve will replace the intake rate. Also, the depth of flow and the shape of the water surface will replace the rate of advance. And temperature of water is a good index to fluid characteristics of viscosity and density.

The following section defines further the meaning and importance of each of these variables and discusses briefly the present status of each.

Rate of Application

The rate at which water is applied to the field is one of the basic variables governing good irrigation design. Methods of measuring the amount of water delivered to the field are available. Weirs, Parshall flumes, and meters are in general use. Improvement is needed, but the present status of water measurement is not a serious restriction to the general problem of the hydraulics of surface irrigation. The principle need is for more measurements of applied water.

Intake Rate

One of the most complex aspects of the hydraulics of surface irrigation is the variable rate at which water enters the soil. Not only does it vary with soil type but with tillage, surface debris, vegetative cover, season, climate, etc. Characteristics of surface flow are greatly influenced by the intake rate.

Tremendous sums of money have been spent collecting data on the intake rate. Considerable effort and money has subsequently been spent trying to analyze the data. Very little has ever been published. Too many variables were involved, being allowed to vary at random, often unmeasured, and frequently ignored. The answer to this component of the general irrigation problem lies in the careful analysis and in controlled experimentation wherein the variables involved are known, the nature of their influence predicted, and these variables either eliminated, held constant, or measured. Only thereby will order come out of the chaos that now surrounds this important component of irrigation.

The fundamental nature of the intake phenomena has been discussed by a number of capable scientists.[2,3,4,5,6,7] The author has summarized these results and drawn conclusions from analysis of the data showing the engineering significance of the fundamental relationships.[8] Additional controlled research is needed to verify the proposed relationships and to develop techniques that can easily be used in the field to obtain data capable of interpretation.

Considerable attention has been devoted to developing field methods of obtaining intake data. An excellent summary has been recently published by the U. S. Dept. of Agriculture.[9]

Another noteworthy step forward has been made by the American Society of Agricultural Engineers through its soil and water division. The irrigation group of this division has organized a committee on standards for measuring intake rates of soils for irrigation system design. Such coordinating activity by the professional societies will do much to stimulate and promote progress in the intake field.

Rate of Advance

The rate that water moves over the surface is of basic importance and is one of the most important characteristics of surface irrigation. Direct measurements can be made and indeed many measurements have been made. Nevertheless, their interpretation is difficult, if not impossible, until the hydraulics of the flow are evaluated.

Surface Roughness

Roughness of the surface over which the water flows relates to both the soil surface and the vegetation within the flow channel. For example, border irrigation of alfalfa is influenced by the alfalfa crowns and stems as well as by the characteristics of the soil surface. The roughness characteristic of a grassed surface-drainage channel will depend upon the velocity of the flow. If the water moves through the vegetation, the roughness will be one value; whereas if the velocity is fast enough to bend over the vegetation, causing the water to flow over the surface of the vegetation, the roughness characteristic will change.

Excellent progress has been made in defining the roughness of pipe. These developments are well outlined in most fluid mechanics texts. Several semi-empirical flow formulas have been developed for open channels. In these developments the roughness has not been nearly as completely defined as in the case of pipe flow.

The major need today is for the evaluation of a coefficient of roughness for open channel flow. The coefficient needs to be evaluated in terms of the

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